Listing of Claims

1. (Original) A method of detecting the location and luminance transition range of a slant image edge in a digital image comprising pixels, the method comprising the steps of:

(a)defining a two-dimensional window in the digital image;

(b) determining a variance value for a plurality of pixels around a selected pixel inside the window;

(c)based on the variance value, determining if the selected pixel is in an edge region;

(d) if the selected pixel is in an edge region, then generating a binary pattern for the pixels in the window based on the mean value of at least said plurality of pixels in the window, the binary pattern comprising binary values corresponding to the pixel values;

(e) based on the binary pattern data, determining if the selected pixel is essentially a center pixel in a luminance transition range of a slant edge; and

(f) if the selected pixel is essentially a center pixel in a luminance transition range of a slant edge, then determining the length of the luminance transition range of the slant image edge.

2. (Original) The method of claim 1, wherein:

in step (a) the window is a W x H window including $L = W$ x H pixels, wherein the window is centered around the selected pixel; and

in step (b) determining a variance value σ for said plurality of pixels is according to the relation:

$$\sigma = \frac{1}{L} \sum_{i=-1,0,1} \sum_{j=-\frac{W-1}{2}}^{\frac{W-1}{2}} |I_{i,j} - m|$$

wherein i, j are row and column indices for the window,

$I_{i,j}$ represents the luminance value of a window pixel $p_{i,j}$ at row i and column j, such that selected pixel is at row 0, column 0, and

m represents the mean value of said plurality of pixels.

3. (Original) The method of claim 2, wherein:

$$m = \frac{1}{L} \sum_{i=-1,0,1} \sum_{j=-\frac{W-1}{2}}^{\frac{W-1}{2}} I_{i,j} \quad .$$

4. (Original) The method of claim 1, wherein in step (c) determining if the selected pixel is in an edge region, further comprises the steps of:

comparing said variance value to a threshold T; and

if the variance value is not smaller than T, then the selected pixel is in an edge region.

5. (Original) The method of claim 1, wherein in step (e) the binary pattern data are used in a pattern matching process to determine if the selected pixel is the center pixel in a luminance transition range of an approximately $\pm 45^{\circ}$ direction edge, and if no pattern is matched, then based on the binary pattern data, performing a checking process to determine if the selected pixel is a center pixel in a luminance transition range other

than an approximately ± 45° direction edge.

6. (Original) The method of claim 1, wherein step (f) further includes the steps of: if the selected pixel is determined to be a center pixel in a luminance transition range of an approximately ± 45° direction edge, then considering the length of the luminance transition range as three pixels wide without performing further checking, otherwise, if the selected pixel is determined to be a center pixel in a luminance transition range other than an approximately ± 45° direction edge, then determining the luminance transition range based on the binary pattern data.

7. (Original) The method of claim 1, wherein in step (d) generating the binary pattern further comprises the steps of:

determining the mean value of at least said plurality of pixels in the window; and

comparing the luminance value of each pixel to the mean value, wherein if the pixel luminance value is less than the mean value then a binary value is selected for that pixel, otherwise, another binary value is selected for that pixel, wherein the binary values form said binary pattern.

8. (Original) The method of claim 7, wherein in step (e) the binary values corresponding to the selected pixel and its neighboring pixels are used in a pattern matching process to determine if the selected pixel is the center pixel in a luminance transition range of a slant edge.

9. (Original) The method of claim 8, wherein in step (e) the binary values corresponding to the selected pixel and its neighboring pixels are compared to one or more binary patterns corresponding to said slant edge, wherein if a match is found, then the selected pixel is the center pixel in a luminance transition range of the slant edge.

10. (Original) The method of claim 7, wherein:

in step (a) the window is a W x H window including $L = W$ x H pixels, wherein the window is centered around the selected pixel;

in step (d) the binary values $b_{i,j}$ are defined according to the relation:

$$b_{i,j} = \begin{cases} 0 & \text{if } I_{i,j} < m \\ 1 & \text{if } I_{i,j} \geq m \end{cases}$$

wherein i, j are row and column indices for the window,

$I_{i,j}$ represents the luminance value of a window pixel $p_{i,j}$ at row i and column j, such that selected pixel is at row 0, column 0, and

m represents the mean value of said plurality of pixels; and

in step (e) the binary values corresponding to the selected pixel and its neighboring pixels are used in a pattern matching process to determine if the selected pixel is the center pixel in a luminance transition range of a slant edge.

11. (Original) The method of claim 10, wherein the pattern matching process is performed by comparing the binary values corresponding to the selected pixel and its neighboring pixels, $b_{i,j}$ $i, j = -1,0,1$, with one or more binary patterns corresponding to

said slant edge, wherein if a match is found, then the selected pixel is the center pixel in a luminance transition range of the slant edge.

12. (Original) The method of claim 11, wherein said one or more binary patterns corresponding to said slant edge are selected from the following eight binary patterns:

0 0 1 0 1	1 0 0 1 1	1 1 1 1 1	1 1 1 0 1 1 0 0 1
1 1 0 1 0	0 1 1 0 0	0 0 0 0 0	0 0 0 1 0 0 1 1

13. (Original) The method of claim 1, wherein:

in step (e) determining if the selected pixel is the center pixel in a luminance transition range other than an approximately $\pm 45^{\circ}$ direction slant edge, further comprises the steps of determining if both of the following two relations:

$$(b_{-1,0} - b_{1,0}) * (b_{0,-1} - b_{0,1}) \neq 0,$$

$$\sum_{i=-1,1} \sum_{j=-1,1} | b_{i,j} - b_{i,0} | = 0,$$

are true, such that if both of said two relation are true, then the selected pixel is a center pixel in the luminance transition range other than an approximately $\pm 45^{\circ}$ slant image edge.

14. (Original) The method of claim 13, wherein in step (f) determining the length of the luminance transition range other than an approximately $\pm 45°$ edge further comprises the steps of:

for a column k in the binary pattern, wherein $2 \le k \le \frac{W-1}{2}$, initially selecting $k = 2$, and in a loop indexed around k, performing the steps of:

comparing the binary values in column k and column $-k$ of the binary pattern with those in column $k-1$ and column $-(k-1)$ of the binary pattern, respectively,

if the compared values are the same and $k < \frac{W-1}{2}$, then k is increased by I and the comparison is repeated,

otherwise if the compared values are the same and $k = \frac{W-1}{2}$, then the loop terminates for the selected pixel, and the luminance transition range is selected as W pixels wide centered around the selected pixel, and

if the compared values are not the same, then the loop terminates for the selected pixel, and the luminance transition range is selected as $2*(k-1)+1$ pixels wide centered around the selected pixel.

15. (Original) The method of claim 14, wherein the steps of comparing the binary values in column k and column $-k$ of the binary pattern with those in column $k-1$ and column $-(k-1)$ of the binary pattern, respectively, comprises the steps of determining if the following condition:

$$\sum_{i=-1,0,1}(|b_{i,k}-b_{i,k-1}|+|b_{i,-k}-b_{i,-k+1}|)=0,$$

is true for the selected pixel and its neighboring pixels, such that if the condition is true, then said compared values are the same.

16. (Original) A detection system that detects the location and luminance transition range of a slant image edge in a digital image including pixels, comprising:

an edge region detector that determines if a selected pixel in a two-dimensional window of pixels in the digital image is in an edge region in the window; and

a binary pattern data generator configured such that if the selected pixel is in an edge region, the binary pattern data generator generates a binary pattern for the pixels in the window based on the mean value of a plurality of pixels in the window, the binary pattern comprising binary values corresponding to the pixel values;

a slant edge center locator configured such that if the selected pixel is in an edge region, the slant edge center locator uses a binary pattern comprising binary values that correspond to pixel values in the window, to determine if the selected pixel is essentially a center pixel in a luminance transition range of a slant edge; and

a luminance transition range detector configured such that if the selected pixel is essentially a center pixel in a luminance transition range of a slant edge, then the luminance transition range detector determines the length of the luminance transition range of the slant image edge.

17. (Original) The detection system of claim 16, wherein the edge region

detector further determines a variance value for a plurality of pixels around the selected pixel inside said window, and based on the variance value determining if the selected pixel is in an edge region.

18. (Original) The detection system of claim 17, wherein:

the window is a W x H window including $L = W$ x H pixels, wherein the window is centered around the selected pixel; and

the edge region detector determines a variance value σ for said plurality of pixels is according to the relation:

$$\sigma = \frac{1}{L} \sum_{i=-1,0,1} \sum_{j=-\frac{W-1}{2}}^{\frac{W-1}{2}} |I_{i,j} - m|$$

wherein i, j are row and column indices for the window,

$I_{i,j}$ represents the luminance value of a window pixel $p_{i,j}$ at row i and column j, such that selected pixel is at row 0, column 0, and

m represents the mean value of said plurality of pixels.

19. (Original) The detection system of claim 18, wherein:

$$m = \frac{1}{L} \sum_{i=-1,0,1} \sum_{j=-\frac{W-1}{2}}^{\frac{W-1}{2}} I_{i,j} .$$

20. (Original) The detection system of claim 17, wherein the edge region detector further determines if the selected pixel is in an edge region, by comparing said

variance value to a threshold T, such that if the variance value is not smaller than T, then the selected pixel is in an edge region.

21. (Original) The detection system of claim 16, wherein the binary pattern data generator further determines the mean value of a plurality of pixels in the window, and compares the luminance value of each pixel to the mean value, wherein if the pixel luminance value is less than the mean value then a binary value is selected for that pixel, otherwise, another binary value is selected for that pixel, wherein the binary values form said binary pattern.

22. (Original) The detection system of claim 16, wherein the slant edge center locator further uses the binary pattern data to determine if the selected pixel is the center pixel in a luminance transition range of an approximately $\pm 45^{\circ}$ direction edge, and if no pattern is matched, then based on the binary pattern data, performs a checking process to determine if the selected pixel is a center pixel in a luminance transition range other than an approximately $\pm 45^{\circ}$ direction edge.

23. (Original) The detection system of claim 22, wherein the slant edge center locator further uses the values of the selected pixel and its neighboring pixels in a pattern matching process to determine if the selected pixel is the center pixel in a luminance transition range of a slant edge.

24. (Original) The detection system of claim 16, wherein the luminance

transition range detector is further configured such that if the selected pixel is essentially a center pixel in a luminance transition range of an approximately $\pm 45^{\circ}$ direction edge, then the length of the luminance transition range is considered three pixels wide without performing further checking, otherwise, if the selected pixel is determined to be a center pixel in a luminance transition range other than an approximately $\pm 45^{\circ}$ direction edge, then the luminance transition range detector determines the luminance transition range based on the binary pattern data.

25. (Original) The detection system of claim 21, wherein:

the window is a W x H window including $L = W$ x H pixels, wherein the window is centered around the selected pixel;

the binary values $b_{i,j}$ are defined according to the relation:

$$b_{i,j} = \begin{cases} 0 & \text{if } I_{i,j} < m \\ 1 & \text{if } I_{i,j} \geq m \end{cases}$$

wherein i, j are row and column indices for the window,

$I_{i,j}$ represents the luminance value of a window pixel $p_{i,j}$ at row i and column j, such that selected pixel is at row 0, column 0, and

m represents the mean value of said plurality of pixels; and

the slant edge center locator uses the binary values corresponding to the selected pixel and its neighboring pixels in a pattern matching process to determine if the selected pixel is the center pixel in a luminance transition range of a slant edge.

26. (Original) The detection system of claim 25, wherein the slant edge center locator performs the pattern matching process by comparing the binary values corresponding to the selected pixel and its neighboring pixels, $b_{i,j}$ $i, j = -1,0,1$, with one or more binary patterns corresponding to said slant edge, wherein if a match is found, then the selected pixel is the center pixel in a luminance transition range of the slant edge.

27. (Original) The detection system of claim 26, wherein said one or more binary patterns corresponding to said slant edge are selected from the following eight binary patterns:

0 0 1 0 1	1 0 0 1 1	1 1 1 1 1	1 1 1 0 1 1 0 0 1
1 1 0 1 0	0 1 1 0 0	0 0 0 0 0	0 0 0 1 0 0 1 1

28. (Original) The detection system of claim 27, wherein:

the luminance transition range detector determines if the selected pixel is the center pixel in a luminance transition range of other than said slant edge direction, by determining if both of the following two relations:

$$(b_{-1,0} - b_{1,0}) * (b_{0,-1} - b_{0,1}) \neq 0,$$

$$\sum_{i=-1,1} \sum_{j=-1,1} | b_{i,j} - b_{i,0} | = 0,$$

are true, such that if both of said two relation are true, then the selected pixel is a center pixel in the luminance transition range other than an approximately $\pm 45^{\circ}$ slant image edge.

29. (Original) The detection system of claim 28, wherein the luminance transition range detector further determines the length of the luminance transition range other than an approximately $\pm 45^{\circ}$ direction edge by a process loop, such that for a column k in the binary pattern, wherein $2 \le k \le \frac{W-1}{2}$, and initially $k = 2$, and in said loop indexed around k, the luminance transition range detector:

compares the binary values in column k and column $-k$ of the binary pattern with those in column $k-1$ and column $-(k-1)$ of the binary pattern, respectively,

checks if the compared values are the same and $k < \frac{W-1}{2}$, and if so, then increases k by 1 and repeats the comparison,

checks if the compared values are the same and $k = \frac{W-1}{2}$, and if so, then terminates the loop for the selected pixel, and selects the luminance transition range as W pixels wide centered around the selected pixel, and

checks if the compared values are not the same, and if so, then terminates the loop for the selected pixel, and selects the luminance transition range as $2*(k-1)+1$ pixels wide centered around the selected pixel.

30. (Original) The detection system of claim 29, wherein the luminance transition range detector compares the binary values in column k and column $-k$ of the binary pattern with those in column $k-1$ and column $-(k-1)$ of the binary pattern, respectively, by determining if the following condition:

$$\sum_{i=-1,0,1}(|b_{i,k}-b_{i,k-1}|+|b_{i,-k}-b_{i,-k+1}|)=0,$$

is true for the selected pixel and its neighboring pixels, such that if the condition is true, then said compared values are the same.